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A study of adaptable architecture pertinence in Iran

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Abstract

The first issue that was revealed in studying building industry in Iran is that a large number of financial capitals invest in building sector; nevertheless a great portion of demolition occurs in buildings, which should remain longer. At the next level the role of adaptable architecture in postponing the demolition trend to increase the useful life span of the buildings is studied. Economic feasibility and energy-environmental considerations are two key factors in adaptability justification. The decision over choosing adaptable architecture should be taken with long-term perspective.

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Keywords: AdaptableArchitecture, Useful life span, Desirable life span, Demolition, Econimic, Environmental consideration;

Introduction

Useful and desirable lifespan of the buildings are the two main problems which have been in question for years in various ways. Actually, buildings are frequently demolished prior to the end of their useful lifespan. This brings about many economic and social problems including the wastage of the national assets, destruction and contamination of the environment and so forth. First let us explain the notions of 'useful lifespan' and 'desirable lifespan' of the buildings.

Useful lifespan: The actual lifespan of a building prior to its demolition or the end of its occupation period.

Desirable lifespan: The span of life that is considered for the building without its architectural sustainability but with respect to macroeconomic aspects.

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At present, the average useful lifespan of the buildings in Iran is 30 years. [1] The problem is that a great portion of the national capital funds are directed to an industry whose products last 30 years. Furthermore, lack of competitive financial market to the building sector, and high degree of construction employment has made it a pivotal industry around which pertinent industries have emerged, so much so that about 40% of the whole investments made nationwide each year are directed to this sector. [2]

Nomenclature

b_1	Initial construction cost of conventional building
b'_1	Initial construction cost of adaptable building
α	Cost of design and execution of principles and details of adaptability
m_1	Maintenance cost of building X during its lifespan
r_1	Repair cost of building X during its lifespan
m'_1	Maintenance cost of adaptable building Y before substantial adaptation (before year γ)
r'_1	Repair cost of adaptable building Y before substantial adaptation (before year γ)
b_2	Demolition and initial construction of building X' (year γ)
α'	Substantial adaptation cost of building Y (year γ)
B	Total Construction costs in buildings X and X'
A	Total construction and adaptation costs in building Y
m_2	Maintenance cost of building X' during its lifespan
r_2	Repair cost of building X' during its lifespan
m'_2	Maintenance cost of adaptable building Y after substantial adaptation (before year λ)
r'_2	Repair cost of adaptable building Y after substantial adaptation (before year λ)
b	The cost of demolition and rebuilding of building X
M	The cost of adequate modernization or rehabilitation in building Y
i	The rate of interest expressed as a proportion
r	The difference in annual repair costs between building X' and Y (after year γ, before year λ)
p	The difference in annual rent costs between building X' and Y (after year γ, before year λ)
r'	The difference in annual repair costs between building X and Y (before year γ)
λ	The useful life of the adapted building Y in years
γ	The useful life of the conventional building X in years
C	Conventional buildings density
T	Adaptable buildings density
p_2	Rent costs of rebuilt buildings in λ year (after year γ)

On the other hand, desirable lifespan of the buildings has been estimated as 65 years in Iran. Since in ideal conditions there is a match between the useful and desirable lifespan, this 35-year gap deserves further attention and research.

Studying the construction patterns in developed nations indicate that on the one hand, with the advancement of the construction technologies, useful lifespan has increased and on the other, low population growth rate in these nations and the sufficiency of building assets has lowered the desirable lifespan. So in these countries the desirable and useful lifespan of the buildings are close to one another, and sometimes useful lifespan proves longer than the desirable lifespan.

1.1. Adaptation in architecture and adaptable architecture

Adaptation in architecture includes any work to a building over and above maintenance to change its capacity, function or performance. [3] Indeed, adaptable architecture can match with the future conditions and needs of the occupants with the least difficulty and cost, and it means more longevity, efficiency and performance particularly in terms of environment preservation. [4]

1.2. Characteristics of adaptable architecture

- Convertibility: allowing for changes in use (economically, legally and technically);
- Dismantlability: capable of being demolished safely, efficiently and speedily – in part or in whole.
- Disaggrgatability: materials and components from any dismantled building should be as much reusable or recyclable as possible.
- Expandability: allowing for increases in volume or capacity (the latter can be achieved by inserting an additional floor in building, which does not increase its volume).
- Flexibility: Enabling minor if not major shifts in space planning to reconfigure the layout and make it more efficient. [3]

Flexibility concerns with changing the character of the space and involves multifunctionalism, but adaptation often involves changes in the physique of the building.

2. Hypothesis

Some researchers believe that adaptable architecture is specific to developed nations because the advanced construction technology paves the way for adaptable architecture to flourish and grow, whereas in developing nations, poor quality construction does not allow this to happen for the occupant. [3] Iran is a country with a dual character, that is, a developing nation that at the same time enjoys some advanced technologies of manufacturing good building materials.

This paper seeks to investigate reasons for the low longevity of the buildings and to find out how, and on what basis it is possible to tackle this problem by taking an adaptable architecture approach.

Actually, the focus of the hypothesis in this research is the usefulness of adaptable architecture in Iran as a means to increase the useful lifespan of the buildings, filling the gap between the desirable and useful lifespans and retarding the demolition of the buildings.

The findings are achieved through field studies and literature reviews.

3. Findings

3.1. Reasons of Demolition

Investigations show that the most frequent causes of demolition in Iran are as follows: [5]

- Economic factors
- Social factors
- Building deterioration
- Incidents and disasters

Also, results obtained in Athena institute, Minnesota show that the most important cause of demolition of the buildings is area redevelopment. [6] The common point resulted from both studies show that, the most frequent causes of demolition lie outside technical areas (such as regional and economic issues, and so forth). Therefore, intervening in the demolition model, reducing the role of uncontrollable and increasing the role of controllable causes can play a significant part in allowing final management of demolition. For example, durable building materials, appropriate design, precise execution of the building details and promotion of periodical building repair and maintenance can ensure the increased strength and reduced susceptibility of the buildings. [5]

In a balanced economy (fig. 1. a) there is a match between deterioration and demolition models and the demolition trend can be controlled by controlling the deterioration trend. Demolition does not take place only due to the minimized capabilities, but happens in a stage of building lifespan when it is still physically desirable, and is demolished as a result of a natural disaster, altered function or non-economic value of the building. [5]

When the land value increases exponentially (fig. 1. b), the two curves corresponding the land value and building value intersect sooner and demolition is advanced.

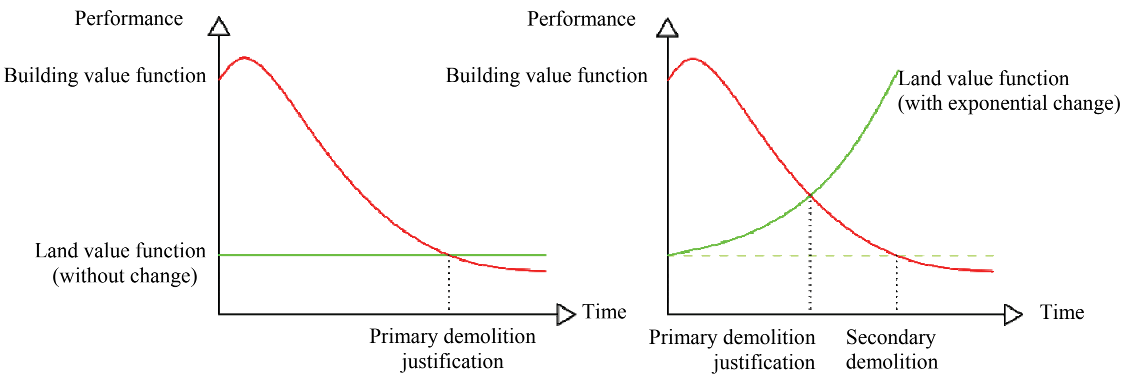


Fig. 1. (a) Building demolition justification because of deterioration; (b) Effect of land value increase on demolition justification

Changes in the land value function take place for the following three reasons:

- Change(s) in land use in upstream urban designs, such as redefining a land use of higher value, like Commercial use.
- Changes in the buildings density on the land in question, when profitability of denser construction in the area justifies the demolition of the existing buildings.

- Higher demand for land where it is of limited availability. When the need for land increases -mostly due to migrations to the urban areas - more land, needs to be allocated to parks, public premises, thoroughfares, streets, roads and so forth. Therefore there will be more qualitative demand for land, and the need for better and more appropriate uses for lands will increase the land value.

These factors are the results of disorders in the upstream urban designs and lack of a guiding system in Land uses and densities inside urban areas.

3.2.. The effects of adaptation on demolition

Today, buildings with less density are demolished and replaced by more dense and more elevated buildings that offer more profits due to higher price of land. In highly dense urban areas the economic value of the building might even fall below the value of the land for a period of time, but demolition and renovation costs will outweigh; the costs involving the new criteria fixed by new laws and regulations. In such conditions, adaptable architecture may increase the value of the building -in technical and economic terms - after it has been adapted, and this retards demolition (fig. 2).

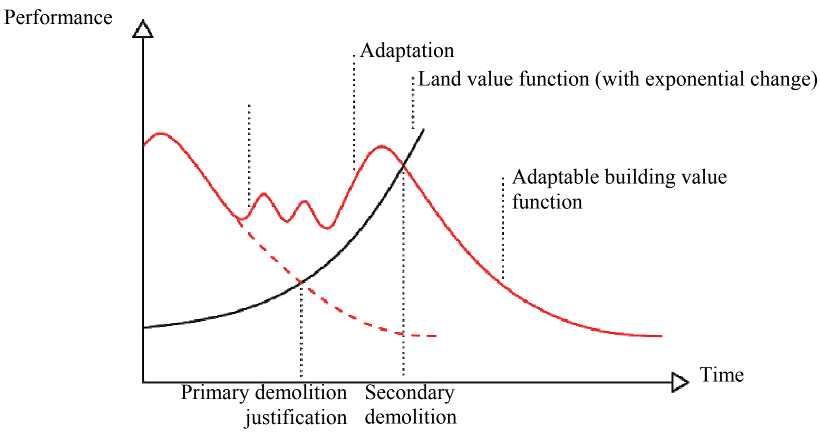


Fig. 2. Adaptable building value function

Adaptable architecture paves the way for the modification and adaptation of the building with the user's demands. So, it aligns with itself the process of repair and maintenance and in many cases facilitates it. [4]

The role played by adaptable architecture changes with alterations in its functions. In many cases users' continuous changes require numerous function shifts that necessitate adaptable architecture. For example in administrative offices, due to changes in the number of the people, and in schools, due to changes in the curriculum, this problem finds more importance. [7]

4. Feasibility of adaptable architecture

4.1. Economic feasibility

In studying the economic feasibility of adaptable architecture, it is necessary to compare it with a building which is similar to it but is not adaptable. Let us continue with the comparison of the conventional and inadaptable building X with building Y which has been designed for adaptability, in the two primary and secondary periods of γ and λ.

Rebuilding will usually be much more expensive than renovation or adaptation. However, the rebuilt buildings have longer life; higher quality function, lower maintenance cost and more rental charge than the repaired and adapted buildings. [8] The initial construction costs in adaptable buildings are higher than that of inadaptable buildings -in design and adaptability details- Therefore:

$$b'_1 > b_1 , b'_1 = b_1 + \alpha \tag{1}$$

Where, b'_1 is the initial construction cost of adaptable building, b_1 is the initial construction cost of conventional building and α is the cost of design and execution of principles and details of adaptability.

In adaptable architecture, repair and maintenance is simpler and takes place according to the desire of the user, and since the possibility of alteration and improvement has been considered in the adaptable architecture, repair and maintenance costs will be lower than in conventional buildings. Therefore:

$$m'_1 < m_1 , r'_1 < r_1 \tag{2}$$

In the comparison made below, two buildings X and Y have been built in year zero. The conventional building X with the initial cost of b_1 and adaptable building Y with the initial cost of b'_1. During γ years the two buildings are maintained and repaired with the costs of m_1 and r_1 (In building X) and m'_1 and r'_1 (In building Y), after γ years building X is demolished and rebuilt at the cost of b_2, whereas building Y is adapted to the new conditions at the cost of A. The two buildings are surveyed λ years after rebuilding and adaptation, while they have been repaired and maintained at the cost of r_2, m_2, r'_2 and m'_2 in this period of time.

Cost	Action		Action	Cost
b_1	Conventional building X design and construction		Adaptable building Y design and construction	b'_1
$r_1 . m_1$	Repair and maintenance during the lifespan		Repair and maintenance before substantial adaptation	$r'_1 . m'_1$
b_2	End of building X lifespan, demolition and construction of building X'	Year	Substantial adaptation of building Y with the present conditions	a'
r_2 , m_2	Repair and maintenance of building X'	Year $\gamma - \lambda$	Repair and maintenance of building Y after adaptation	r'_2 , m'_2
	λ years after rebuilding		λ years after adaptation	
Total costs = $b_1 - r_1 + m_1 + b_2 + r_2 + m_2$			Total costs = $b'_1 - r'_1 + m'_1 + a' - r'_2 + m'_2$	

We use Needleman equation for the comparison:

$$b > M + b(1+i)^{-\lambda} + \left(\frac{r+p}{i}\right)\left[1-(1+i)^{-\lambda}\right] \quad (3)$$

Where b is demolition and rebuilding cost, M is substantial repair cost, $b(1+i)^{-\lambda}$ is the present value of the cost of rebuilding in λ years' time and $\left(\frac{r-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right]$ is the present value of the difference in annual running costs and rents for λ years. [8]

Since the equation above does not include the initial building costs prior to year γ, we can rewrite the equation like below to take into account these costs:

$$B > A + b_2(1+i)^{-\lambda} + \left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right] \quad (4)$$

Where B is the total Construction costs in buildings X, X' and A is the total Construction and adaptation costs in building Y, $\left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right]$ is the differences due to higher rental and less repair and maintenance costs in building X' after year γ and lower repair costs of building Y prior to the year γ.

The equation above applies when the numbers of conventional and adapted buildings units are equal, that is, Conventional buildings density C = T adaptable buildings density. Obviously, constructions have a trend towards building density increase, that is: C >T, therefore equation 4 changes to:

$$TB + (C-T)b_2 > TA + Cb_2(1+i)^{-\lambda} + T\left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right] + (C-T)\left(\frac{r_2-p_2}{i}\right)\left[1-(1+i)^{-\lambda}\right] \quad (5)$$

Were TB is the total construction costs of the T buildings, $(C-T)b_2$ is the construction costs of buildings added to T buildings, TA is the total construction and adaptation costs of T buildings , $Cb_2(1+i)^{-\lambda}$ is the present value of the cost of rebuilding C buildings in λ years' time, $T\left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right]$ is the present value of the difference in annual running costs and rents in T buildings for $\gamma+\lambda$ years and $(C-T)\left(\frac{r_2-p_2}{i}\right)\left[1-(1+i)^{-\lambda}\right]$ is the total rent and repair costs for $(C-T)$ rebuilt buildings in λ years.

Decision making over the construction of adaptable buildings is taken at two levels: at one level, by consideration of changes in the ratio of costs (production, rental and repair) to changes in density, that is $\frac{\text{difference in costs}}{\text{difference in density}}$, and on the other it takes place with the consideration of the urban planning organization and the long-term plans clarification within the area in question.

Rental costs constitute a portion of the construction costs, so we can conclude that:

If we multiply the two sides of the inequation by $(C-T)$:

$$(C-T)b_2 > (C-T)\left(\frac{r_2-p_2}{i}\right)\left[1-(1+i)^{-\lambda}\right] \quad (7)$$

Now if we subtract the inequation thus obtained from inequation 4 we have:

$$TB > TA + Cb_2(1+i)^{-\lambda} + T\left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right] \tag{8}$$

Dividing two sides of inequation by T results as follow:

$$B > A + \frac{C}{T}b_2(1+i)^{-\lambda} + \left(\frac{r+p-r'}{i}\right)\left[1-(1+i)^{-\lambda}\right] \tag{9}$$

If we compare this inequation with inequation 4, we notice that its authenticity is related to the ratio of $\frac{C}{T}$, in a way that the greater the ratio the greater will be the second side of the inequation, which indicates the effect of density change on decision making over adaptable building construction.

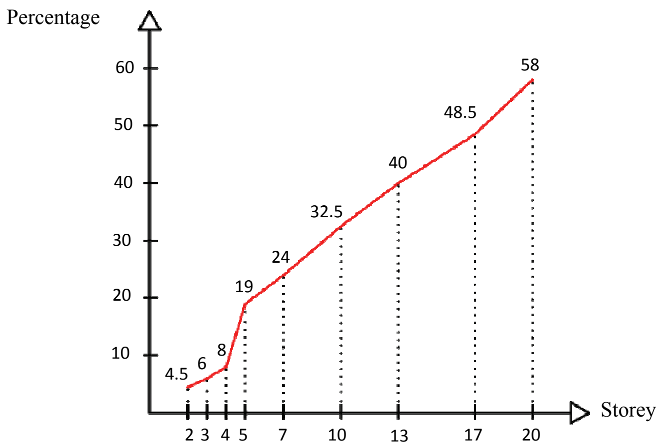


Fig. 3. Extra cost of storey increase in byilding than the same number of one storey unit with the area [9]

4.2. Energy and Environmental Considerations

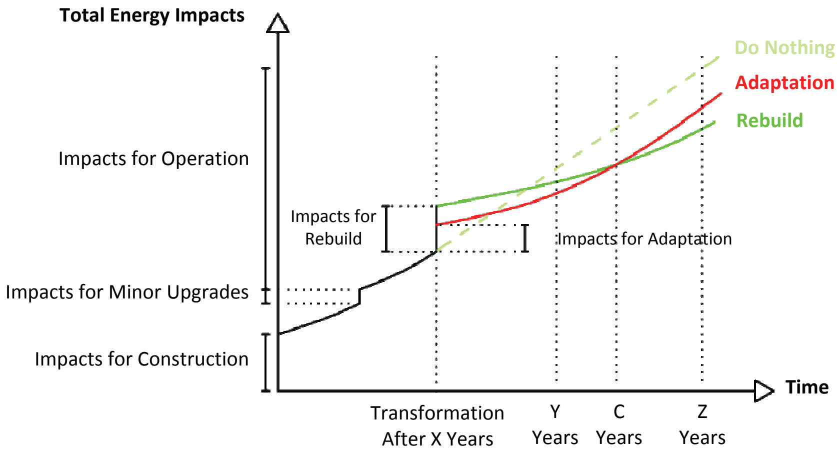
One of the issues which is important to study, and is investigated side by side with economic studies, is the contribution of adaptable architecture to the reduction of the destructive effects on the environment. Better and longer use of the premises, means that we have actually reduced the destructive effects of construction on the environment. [4]

For conventional buildings, the embodied energy represents only 10% of total energy impacts. However, for low energy buildings, where operational energy is greatly reduced, embodied energy can be 40% or higher. This life cycle energy approach can inform the rebuild or adaptation dilemma. A full rebuild can produce a building that operates highly efficiently. However, an entirely new structure requires a large embodied energy investment. In contrast, adaptation leave the main building structure largely unchanged meaning the embodied energy increase is small. However, achieving high operational energy efficiency typically requires an overhaul of old building envelopes and ventilation systems, with embodied energy implications. Contrasting a rebuild with a substantial adaptation is illustrated in figure. 4. The option of doing nothing uses the most energy.

While the rebuilding may have lower life cycle energy, retrofitting can have lower waste generation, resource use and material flows. In addition, existing buildings that are designed to be more adaptable from the start may be easier to upgrade to high energy standards and thus are a better option after Z or even only Y years. [10]

The goal here is not to prolong the useful lifespan of the building as long as it is possible, but to plan it in a way that the intersection happens at the end of building's desirable lifespan.

Reduction of the destructive effects on the environment by adaptation and recycling has been investigated in some case studies (e.g. Nils K. Larsson [4] and Morrison Hershfield [11]).



5. Conclusion

High rate of population growth in Iran and increasing need of Iranians for buildings, as well as high rate of employment this industry offers has directed a great portion of the investments to this sector (estimated at about 40 percent), whereas the product of this industry has only a useful life of about 30 years. With the advancement of technologies, the conventional approach of occupation must change, because in this way, buildings are demolished or obsoleted prior to the end of their desirable lifespan that otherwise could have been about 65 years.

Adaptable architecture is among strategies that can increase the useful lifespan of the buildings and draw it nearer to the desirable lifespan and consequently reduce the destructive effects of demolitions and constructions on the environment. It is because demolitions usually happen due to changes in land use or density, and adaptable architecture can match with these changes. Besides, taking this approach will pay off economically in the long run.

Decisions over using or not using adaptable architecture takes place with the consideration of urban applications, densities allowed in the area and environment pollution due to demolitions and constructions.

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